Nonlinear organic photorefractive polymers and their applications

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Photorefractive polymers are among the most sensitive nonlinear optical recording materials. They exhibit large refractive index changes when exposed to low power laser beams. Discovered and studied for several decades mainly in inorganic crystals and semiconductors, the photorefractive effect has been discovered in organic materials in the 1990s. In recent years, guest-host polymers with nearly 100% diffraction efficiency, increased shelf-life, and ms response-times could be demonstrated.

Here, we will report on the fabrication of photorefractive polymer composites using injection molding (see Fig. 1). This work is a proof-of-principle demonstration that photorefractive polymers can be fabricated using mass production techniques. For our experiments we formulated a photorefractive composite that was known to have good phase stability properties and a high dynamic range. The inert polymer was a commercial birefringence-free acrylic resin, doped with the photorefractive chromophore 2, N, N-dihexylamino-7-dicyano-methyl-idenyl-3, 4, 5, 6, 10-pentahydro-naphthalene (DHADC-MPN), that provides simultaneously transport properties and electro-activity. The composite was plasticized using diphenyl isophthalate (DIP), and sensitized using (2,4,7-trinitro-9-fluorenylidene)-malononitrile (TNFDM). The field dependence of the diffraction efficiency measured in steady-state four-wave mixing experiments performed at 633 nm is shown in Fig. 2.

We will also report on new photorefractive polymers that are sensitized by nonlinear absorption. Regular photorefractive polymers are doped with a sensitizer that often forms a charge transfer complex with the transport moieties. This complex provides optical absorption at the operating wavelength. In contrast, nonlinear photorefractive materials are transparent for low power cw beams and become absorbing at high intensity through multi-photon absorption. In our case, two-photon absorption was provided by the electro-active chromophore. New properties associated with nonlinear absorption including non-destructive read-out and photon gating will be discussed.

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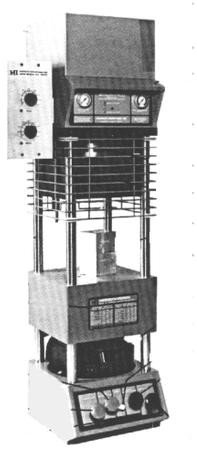

Fig. 1: Photograph of the Morgan Industries G55-T 22 ton vertical travel press used to fabricate by injection molding samples of photorefractive polymers with various shapes and thickness.

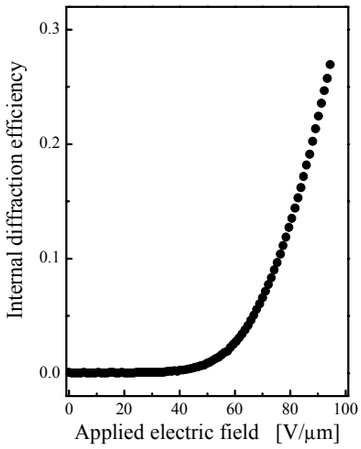

Fig. 2: The diffraction efficiency of an injection-molded photorefractive polymer composite sample as a function of applied field.